Composite microcapsules for delivery of sensitive food ingredients

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Introduction

- Mounting evidence suggesting the health promoting properties of PUFA, antioxidants, phytochemicals and vitamins calls for fortifying foods with these nutrients.
- Capabilities to deliver such ingredients through foods are compromised and limited by the extreme sensitivity of these compounds to oxidative deterioration.
- Microencapsulation is among the most promising technologies that can provide opportunities in overcoming the stated difficulties.
- However, success, in developing stable microencapsulated nutritional lipids and related compounds, for long-term storage, has been less than desired and falls short of what is needed in order to meet current challenges.

Introduction

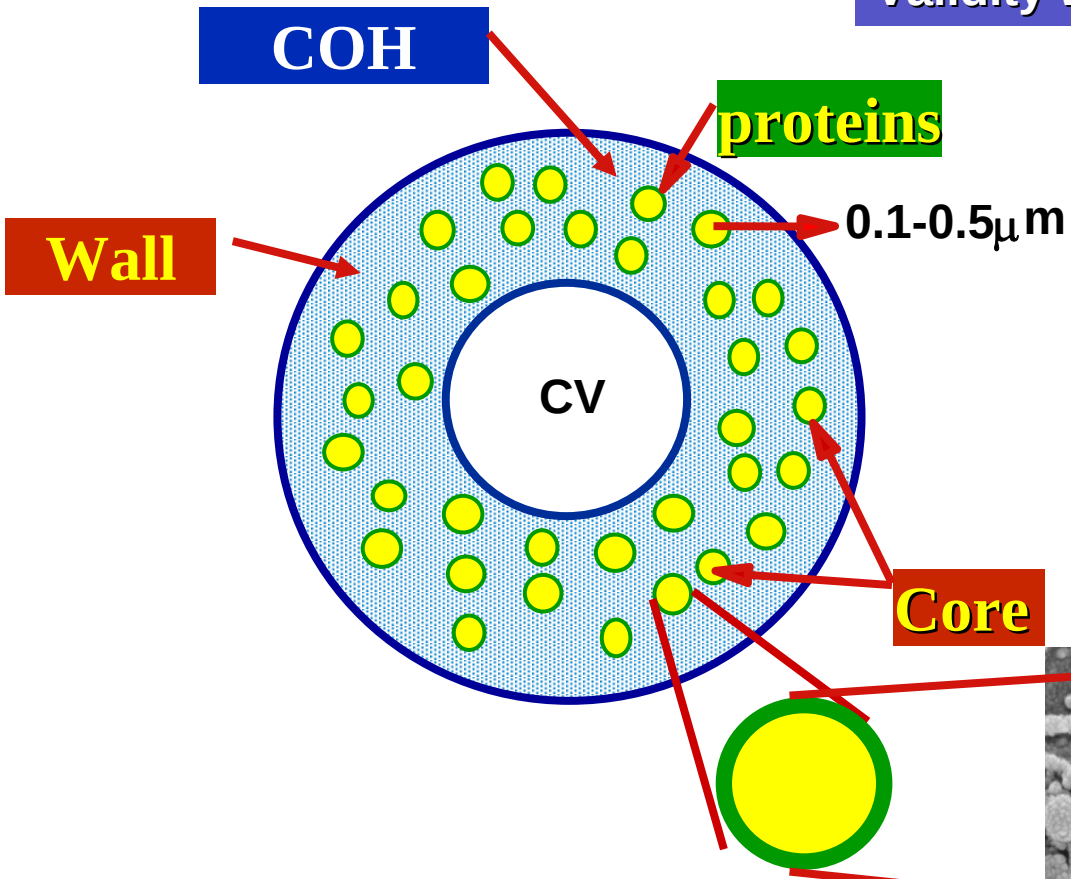
- A need to develop new affective microencapsulating approaches exists.
  - New encapsulating agents
  - New design of microcapsules

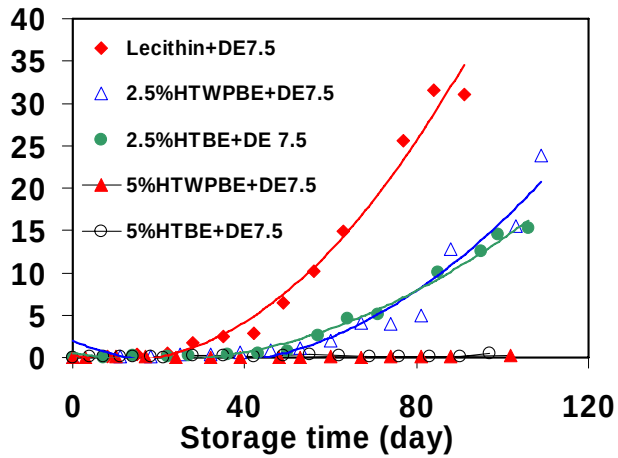
REASERCH HYPOTHESIS

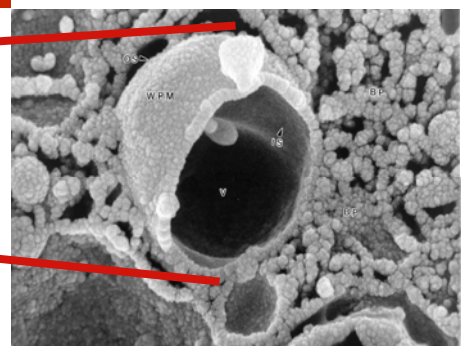
Composite spray dried microcapsules consisting of protein-coated droplets of sensitive core material embedded in wall matrices consisting of carbohydrates provide the encapsulated core with long-term, oxidative stability.

Hypothesis Model of Microcapsules

Validity with WP has been proven



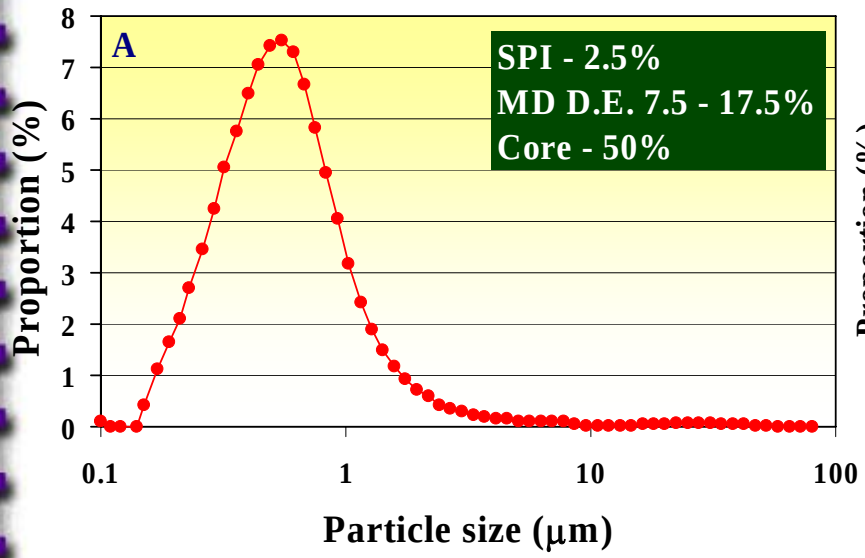


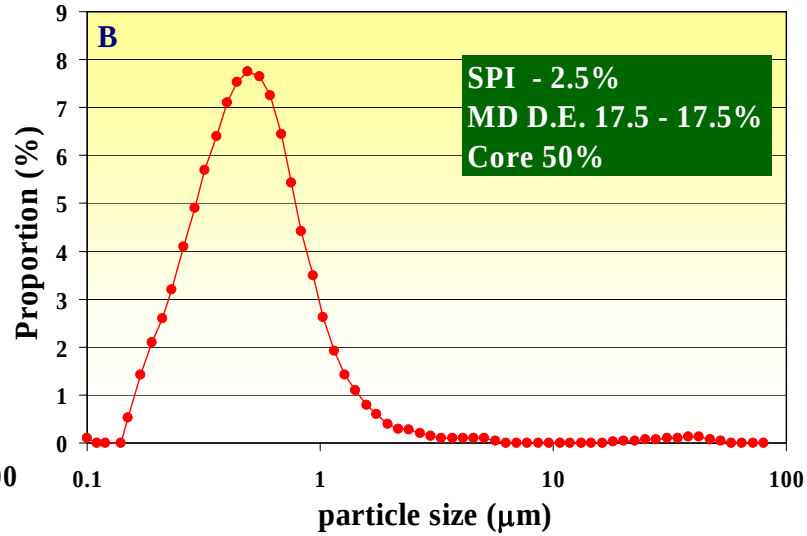


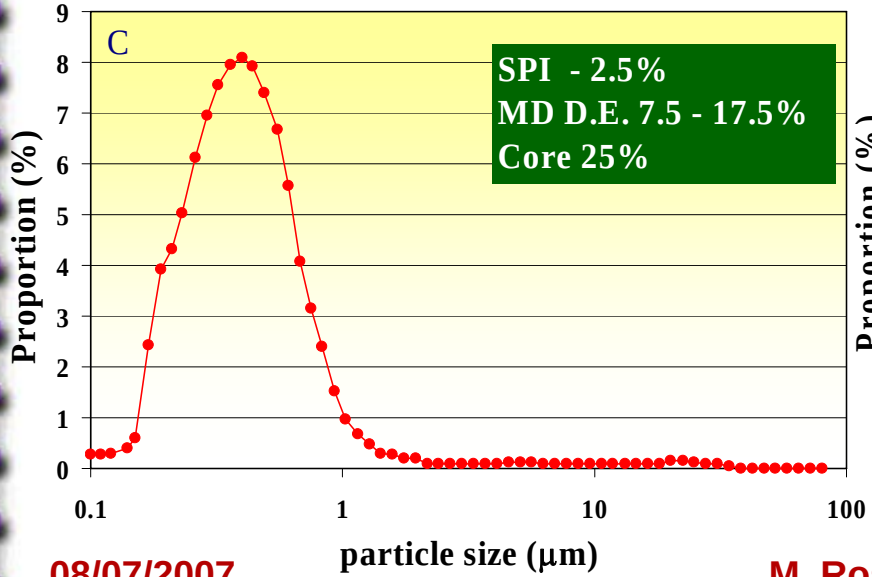
Specific Objectives

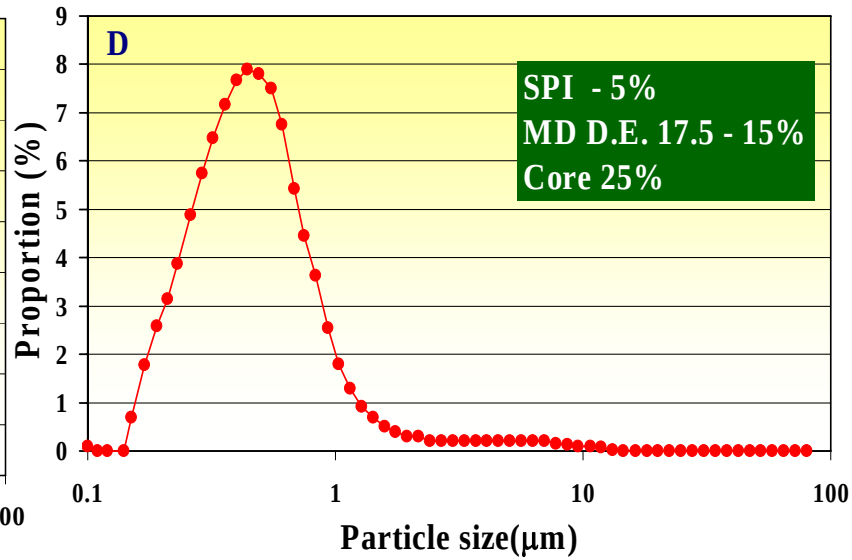
- To investigate the effects of core load, type and load of protein and carbohydrate and of emulsification variables on the formation and properties of Soy- and Zein-stabilized CIWE.
- To investigate the influence of wall composition and physico-chemical properties of the CIWE on the formation composition, microstructure, and functionality of spray-dried microcapsules prepared from these CIWE
- Based on results of objectives 1 & 2, to investigate the role of: type and of protein surface excess, core load, and of wall composition and structure in governing the oxidative stability of the encapsulated core.

Microencapsulating properties of soy proteins

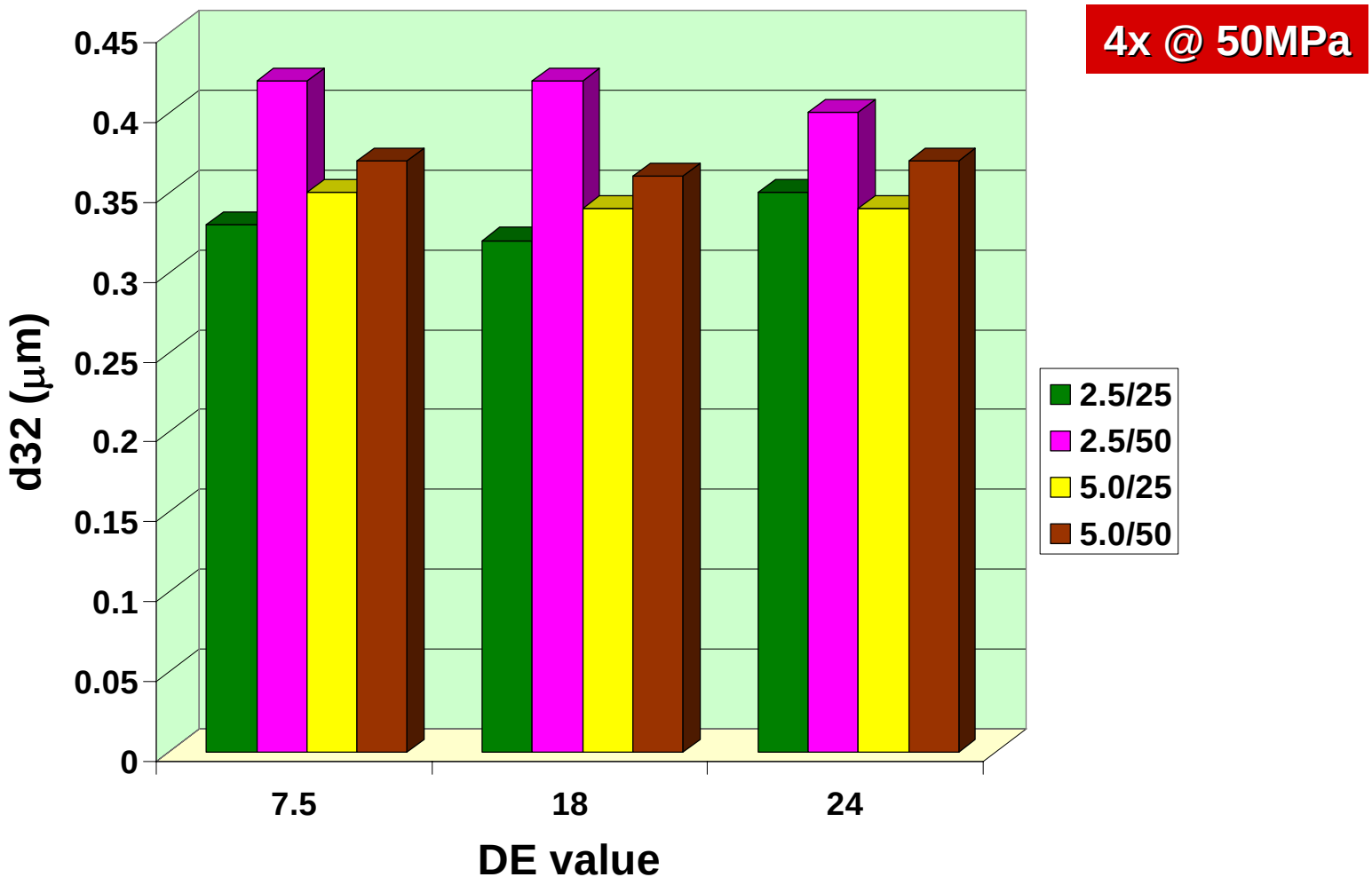

A
SPI - 2.5%
MD D.E. 7.5 - 17.5%
Core - 50%
Proportion (%)
Particle size (μm)


B
SPI - 2.5%
MD D.E. 17.5 - 17.5%
Core 50%
Proportion (%)
particle size (μm)

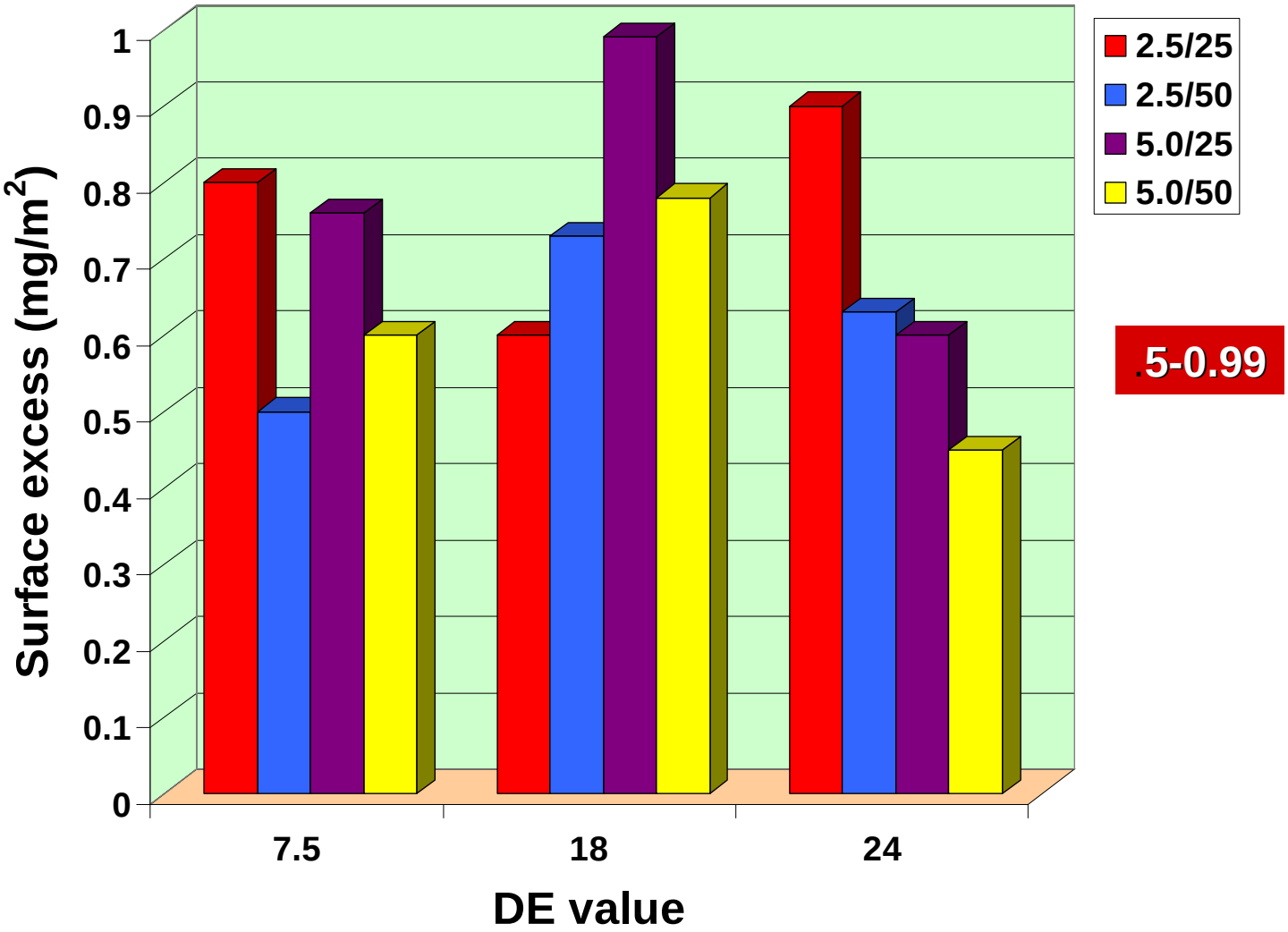

C
SPI - 2.5%
MD D.E. 7.5 - 17.5%
Core 25%
Proportion (%)
particle size (μm)


D
SPI - 5%
MD D.E. 17.5 - 15%
Core 25%
Proportion (%)
Particle size(μm)

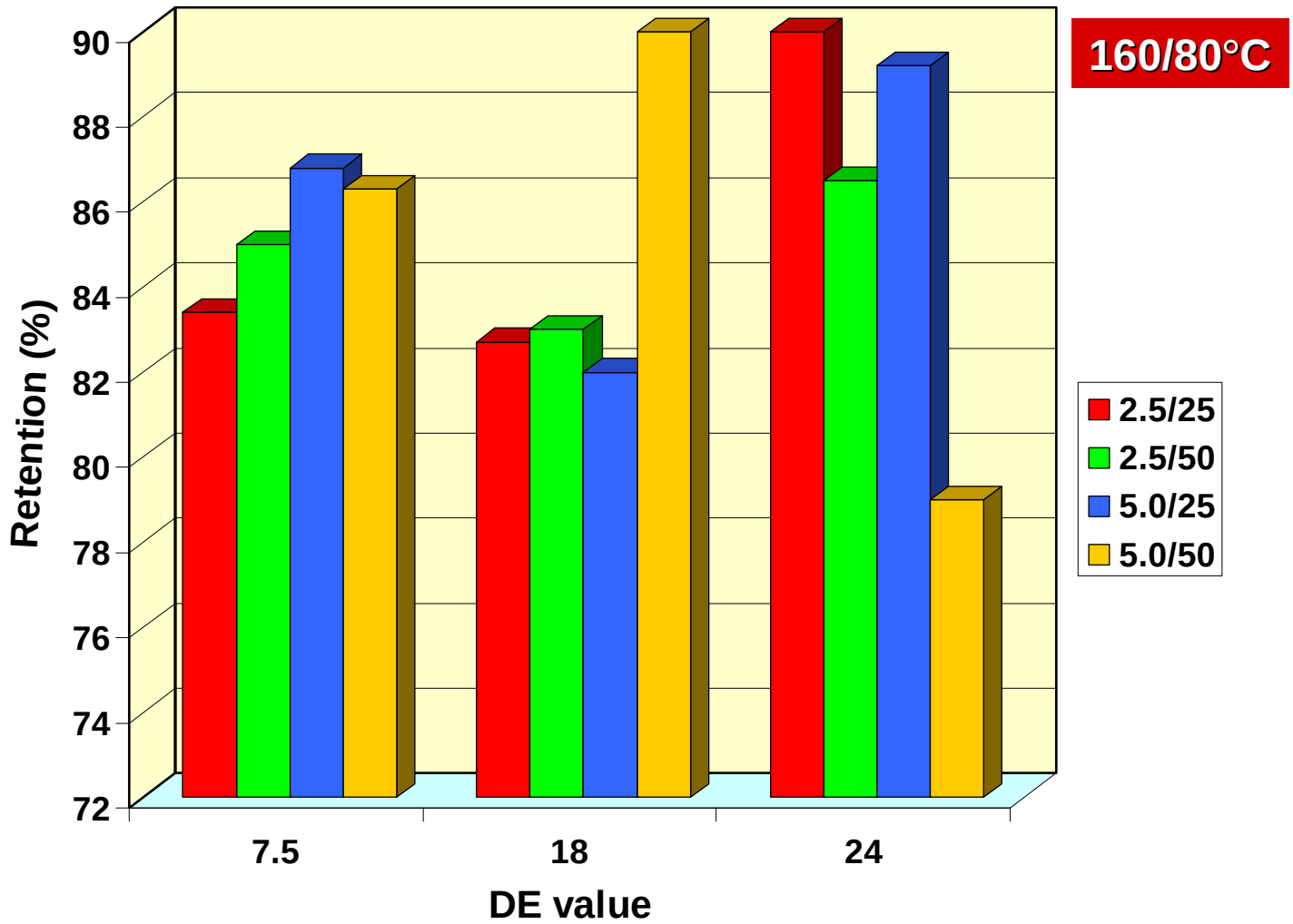
Mean particle size in CIWE



Surface Excess



Core Retention

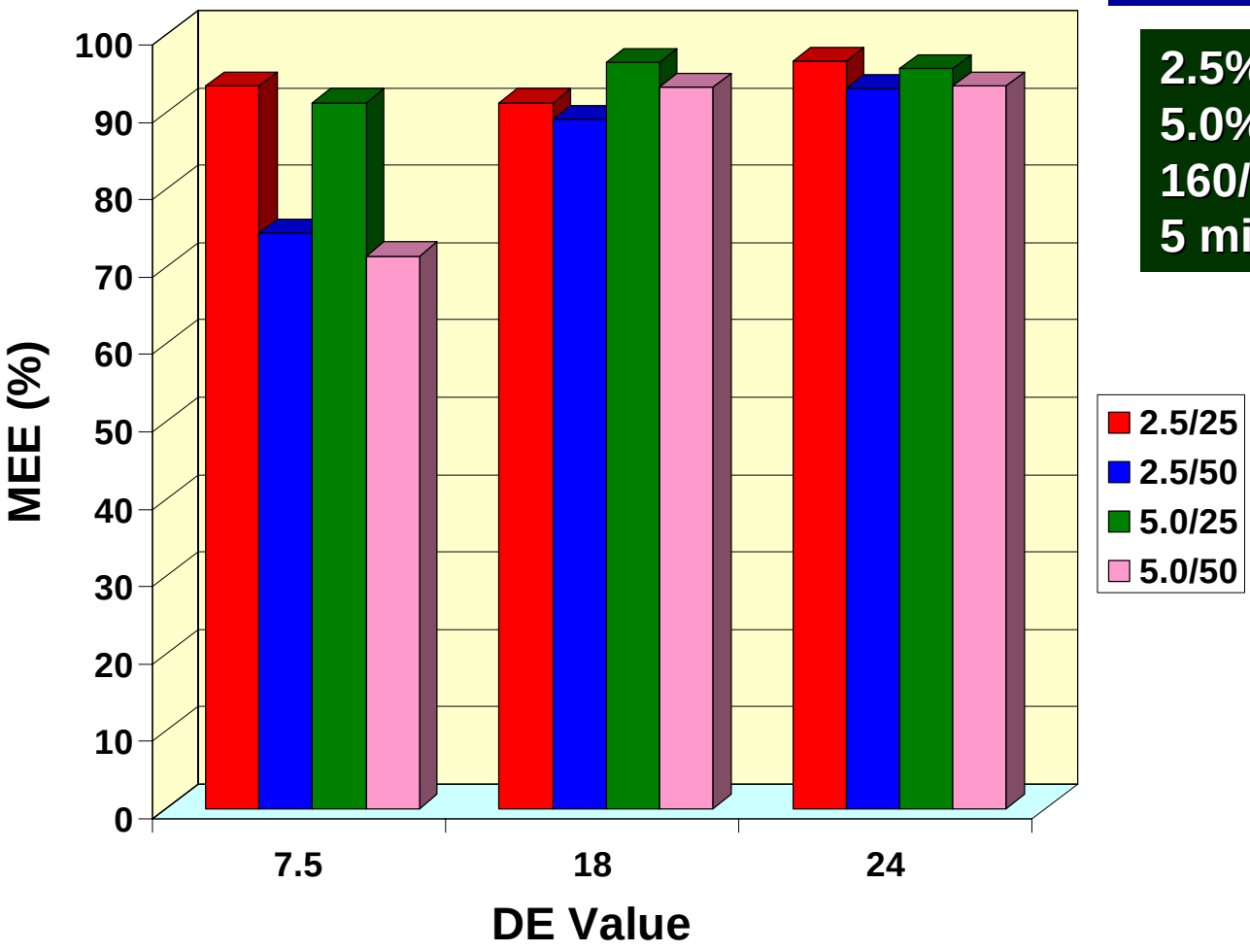


Microencapsulation efficiency (MEE)

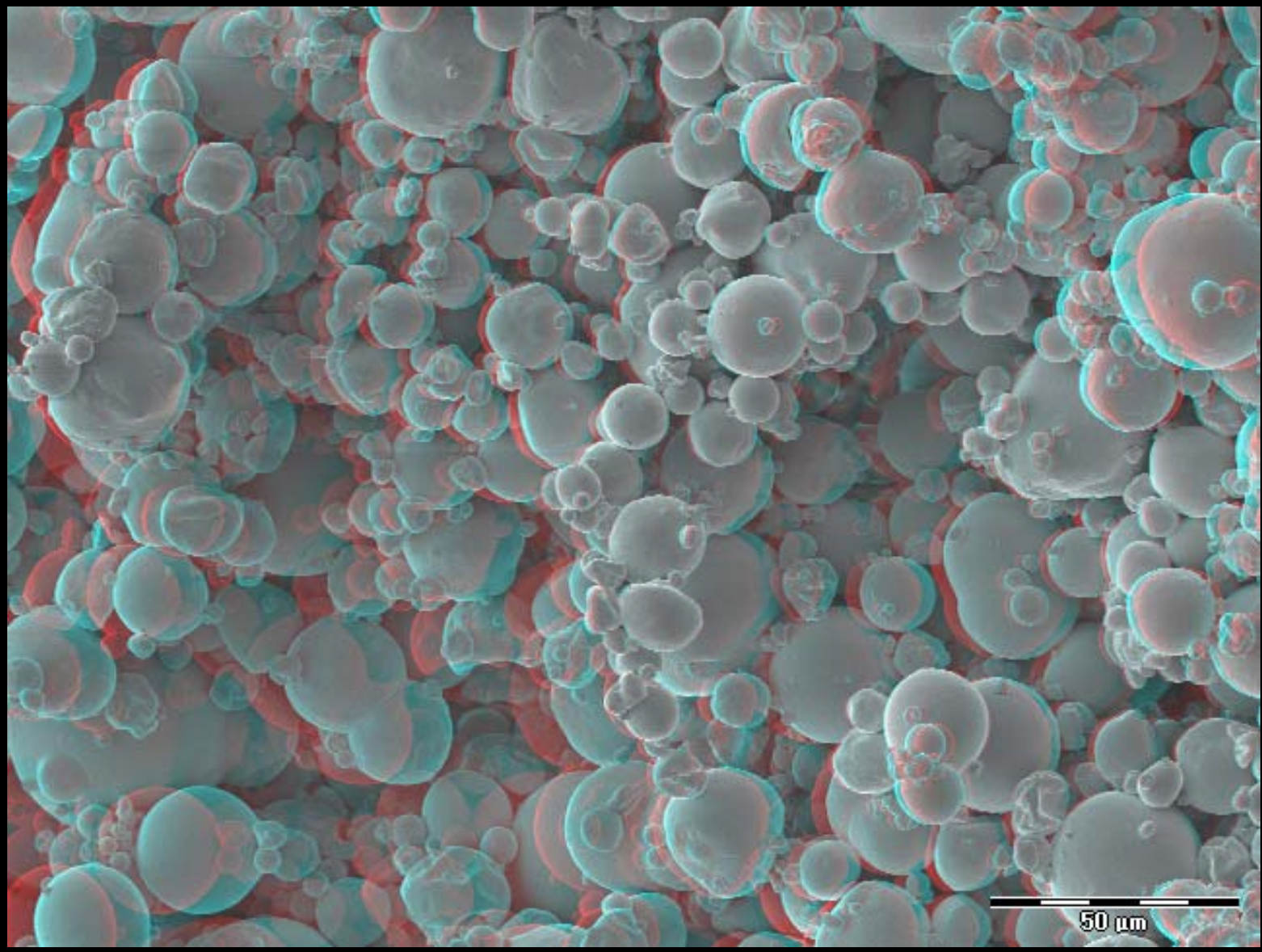
MEE (%)=100-Ext. core

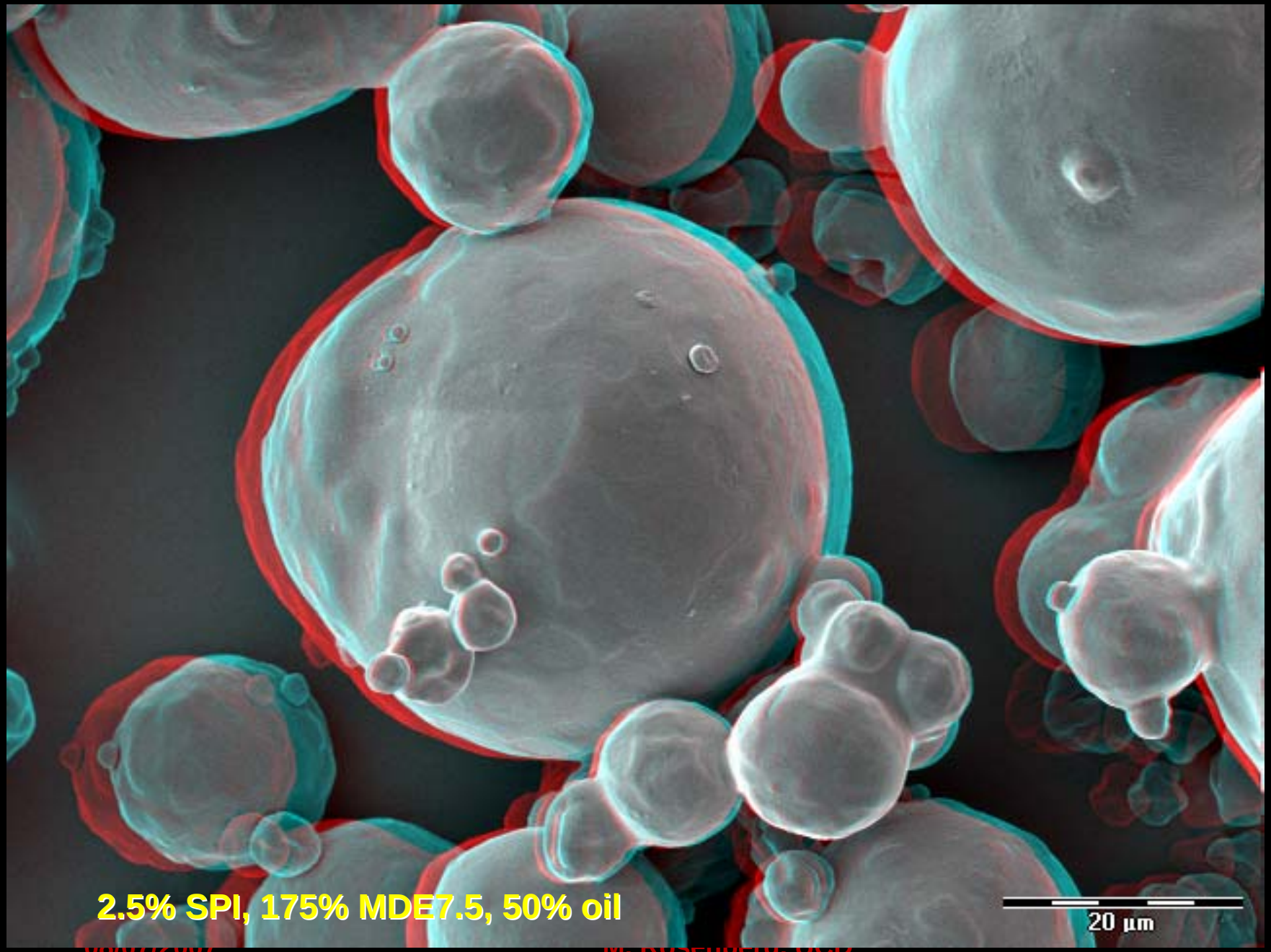
2.5% SPI; 17.5% MD
5.0% SPI; 15%MD
160/80°C
5 min ext.

SPI A

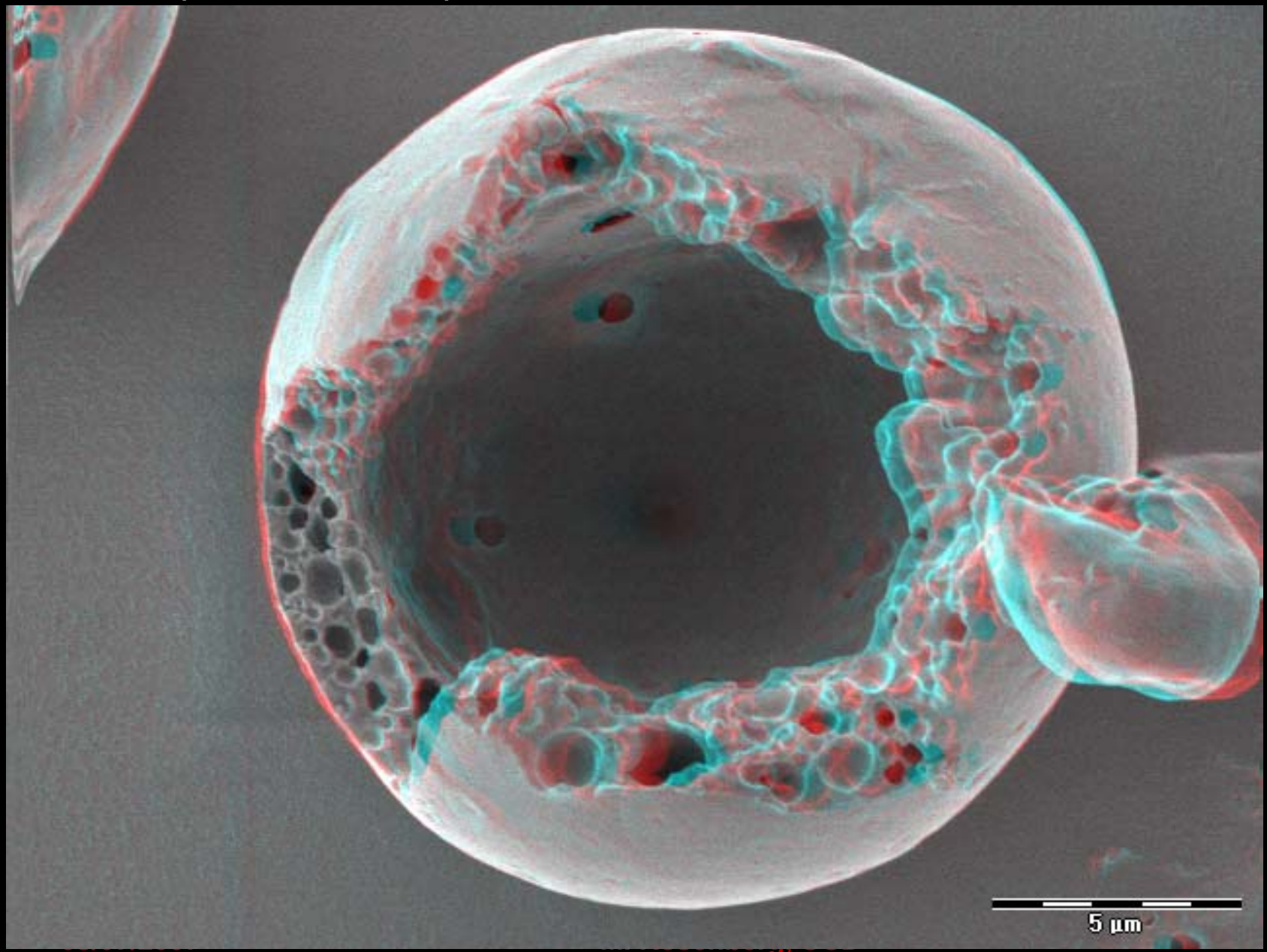


5% SPI, 15% MDE24, 25% OIL

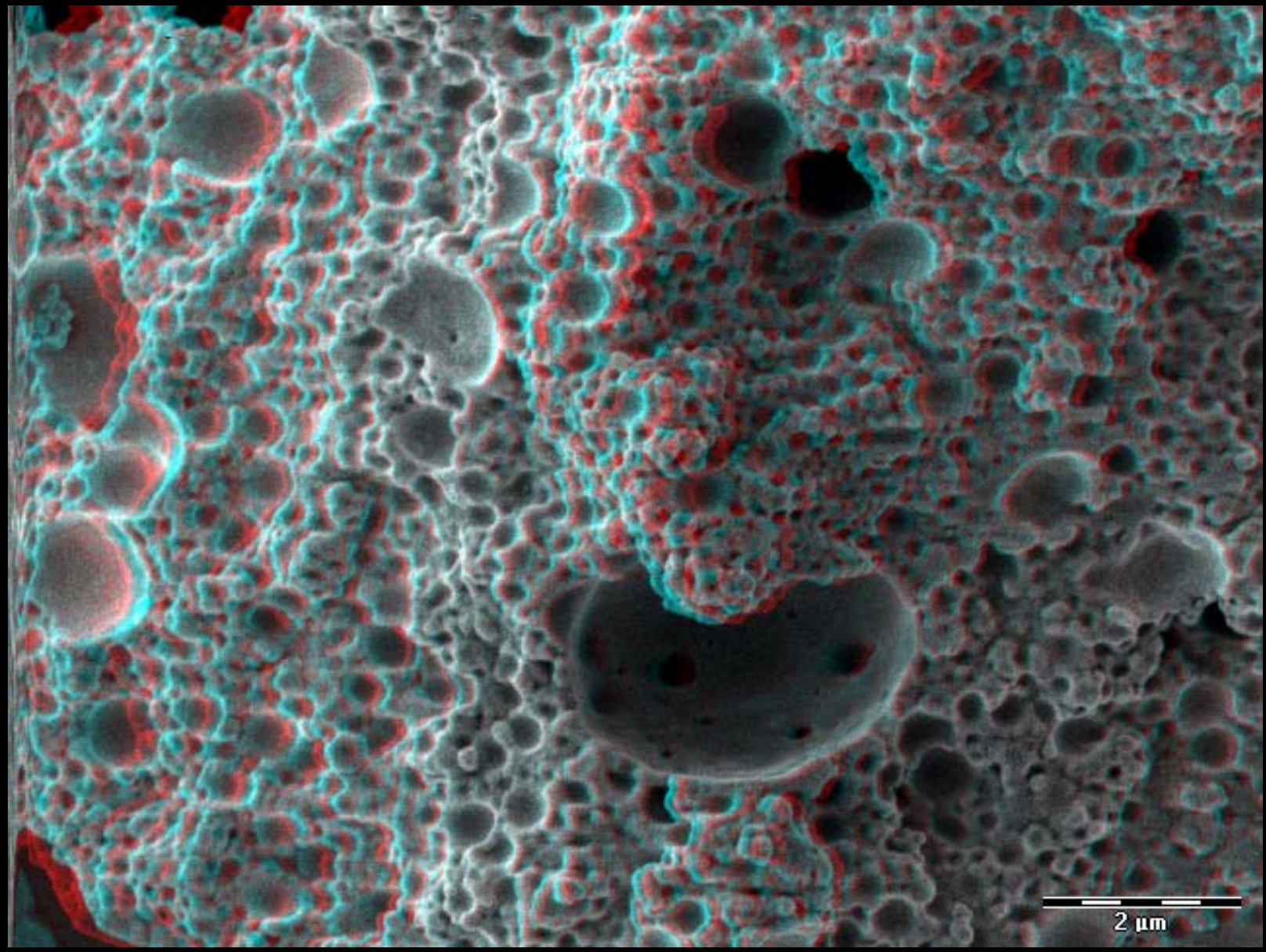



2.5% SPI, 175% MDE7.5, 50% oil
20 µm

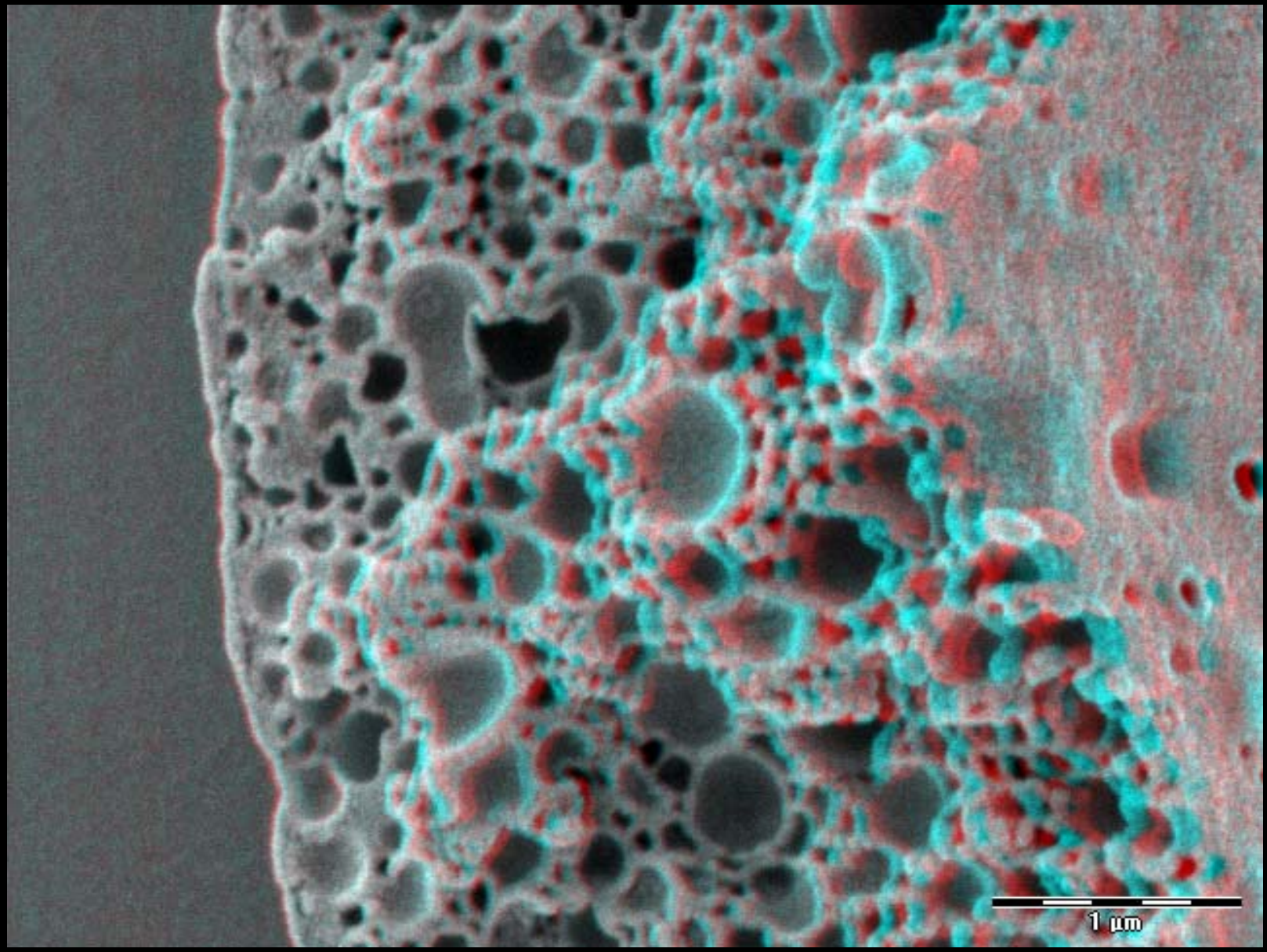
2.5% SPI, 17.5% MDE7.5, 60% oil

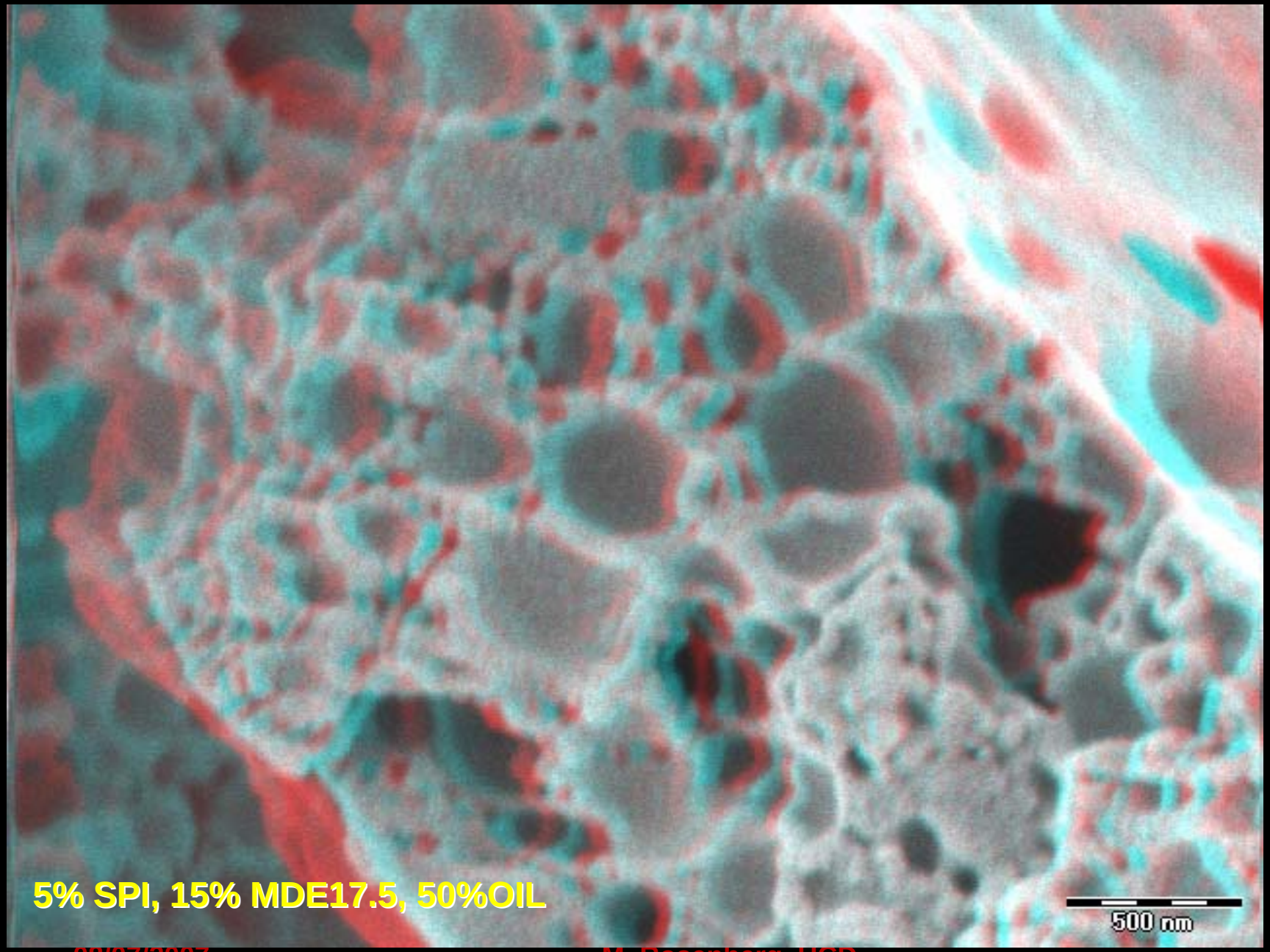


5% SPI, 15% MDE17.5, 50%OIL



5% SPI, 15% MDE17.5, 50%OIL



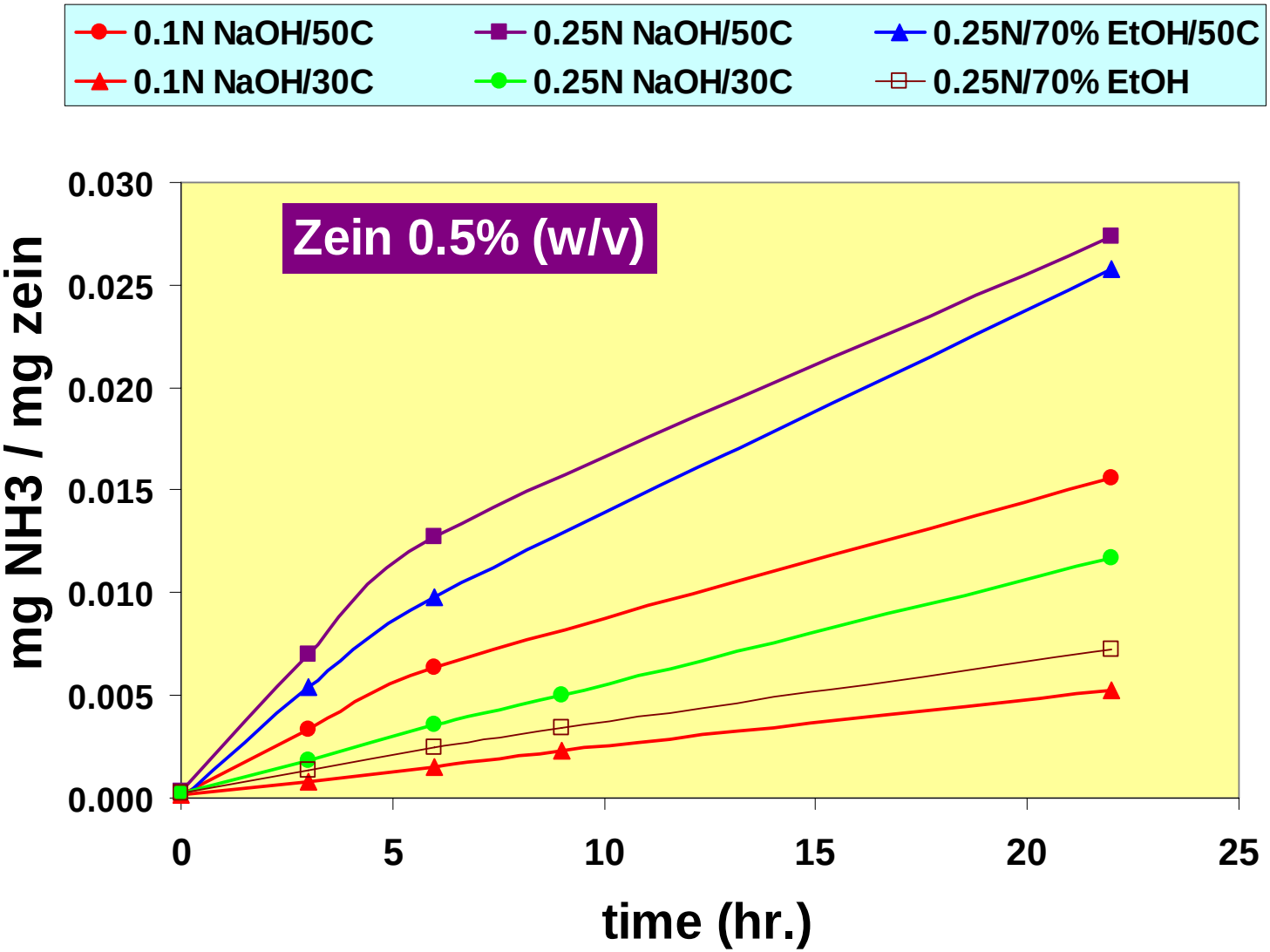

5% SPI, 15% MDE17.5, 50%OIL
500 nm

Zein as microencapsulating agent

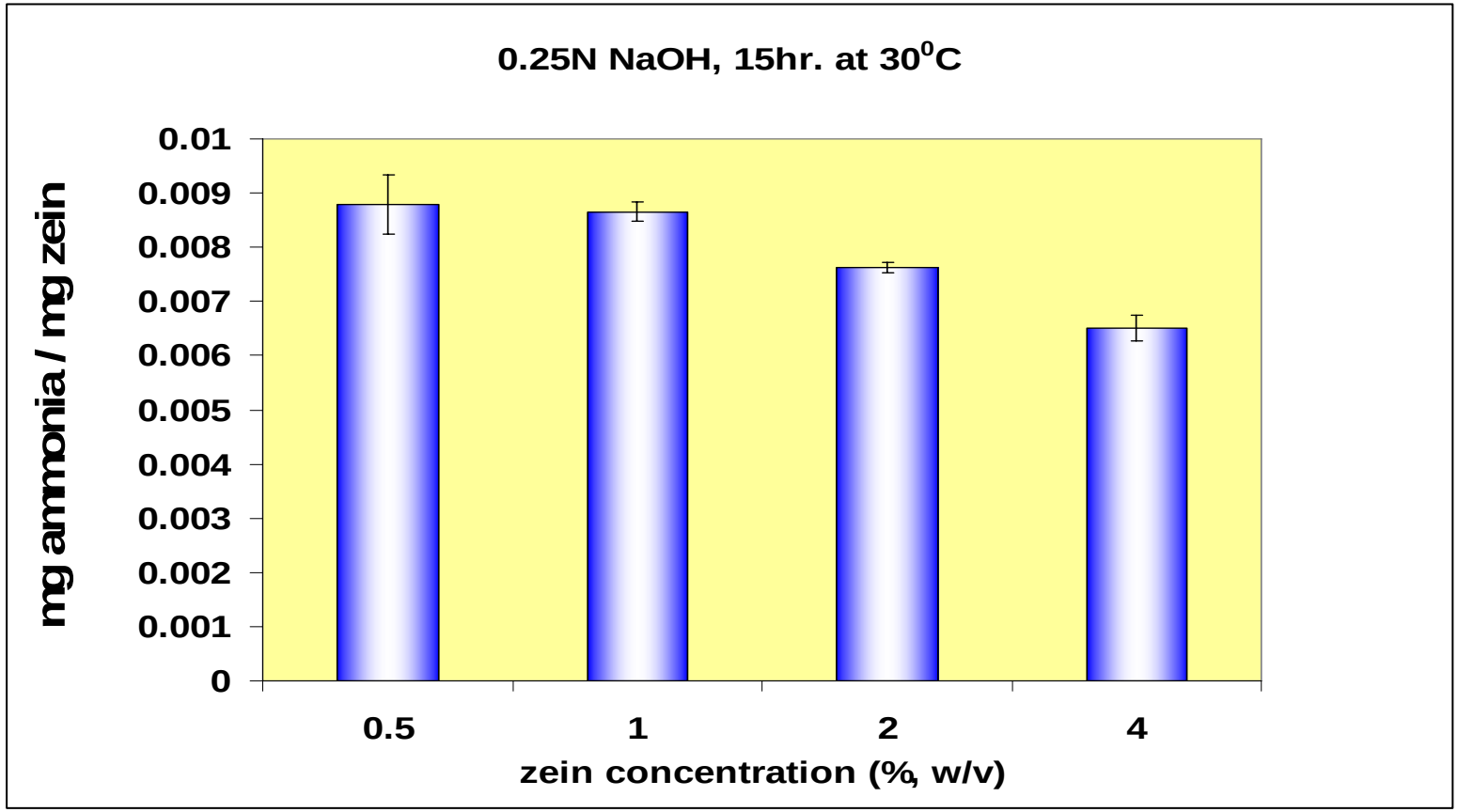
- Prolamin
  - Solubility
    - Alcohol, extreme pH
- Functionality
  - Film forming
  - Drying properties
  - Oxygen barrier properties of films

- Encapsulation with EtOH solution – very limited success
- Aqueous solutions
  - Deamidation at alkaline conditions
    - Extent of deamidation
    - Extent of hydrolysis
    - Solubility
    - Surface activity

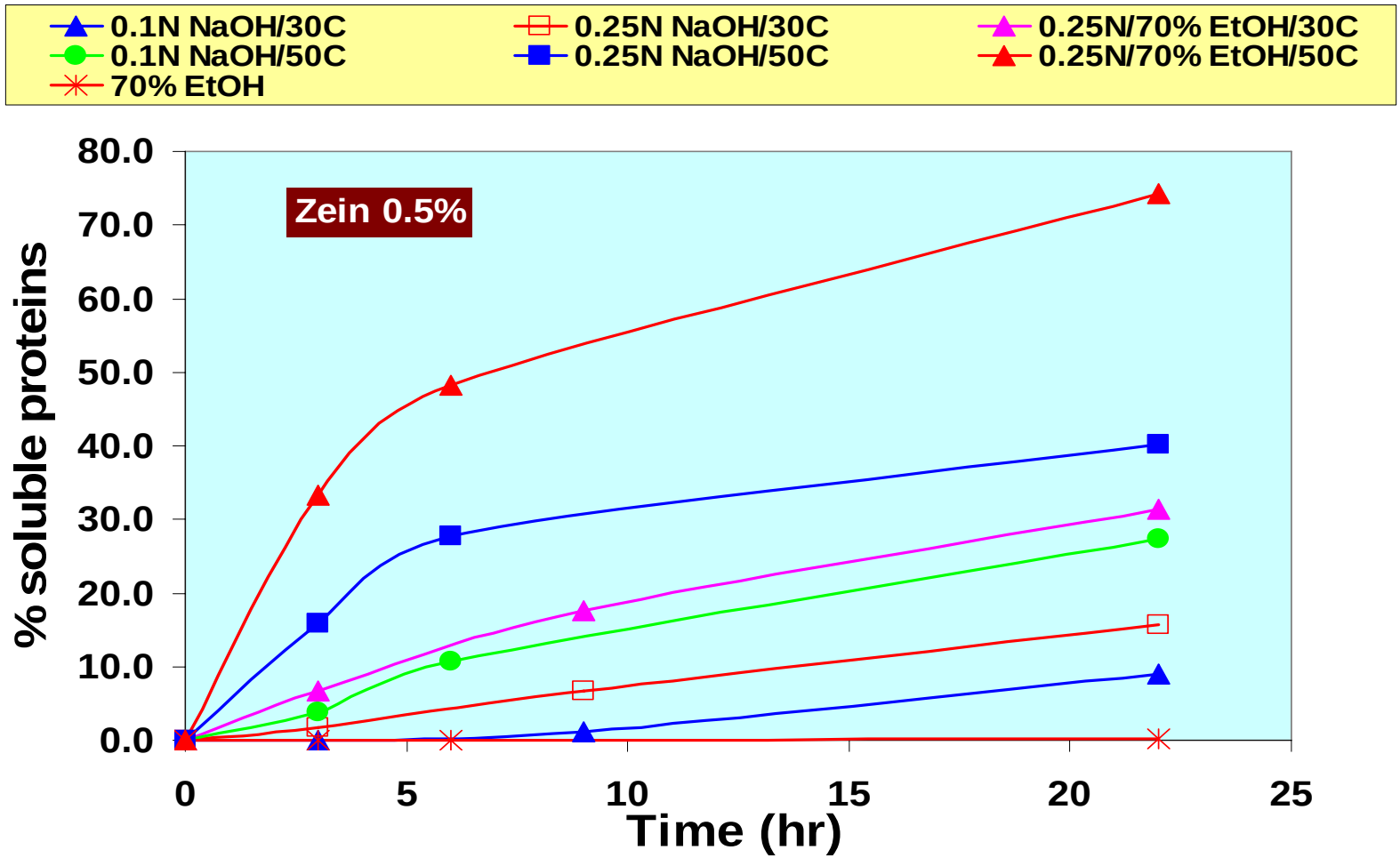
Effect of deamidation conditions on DD:



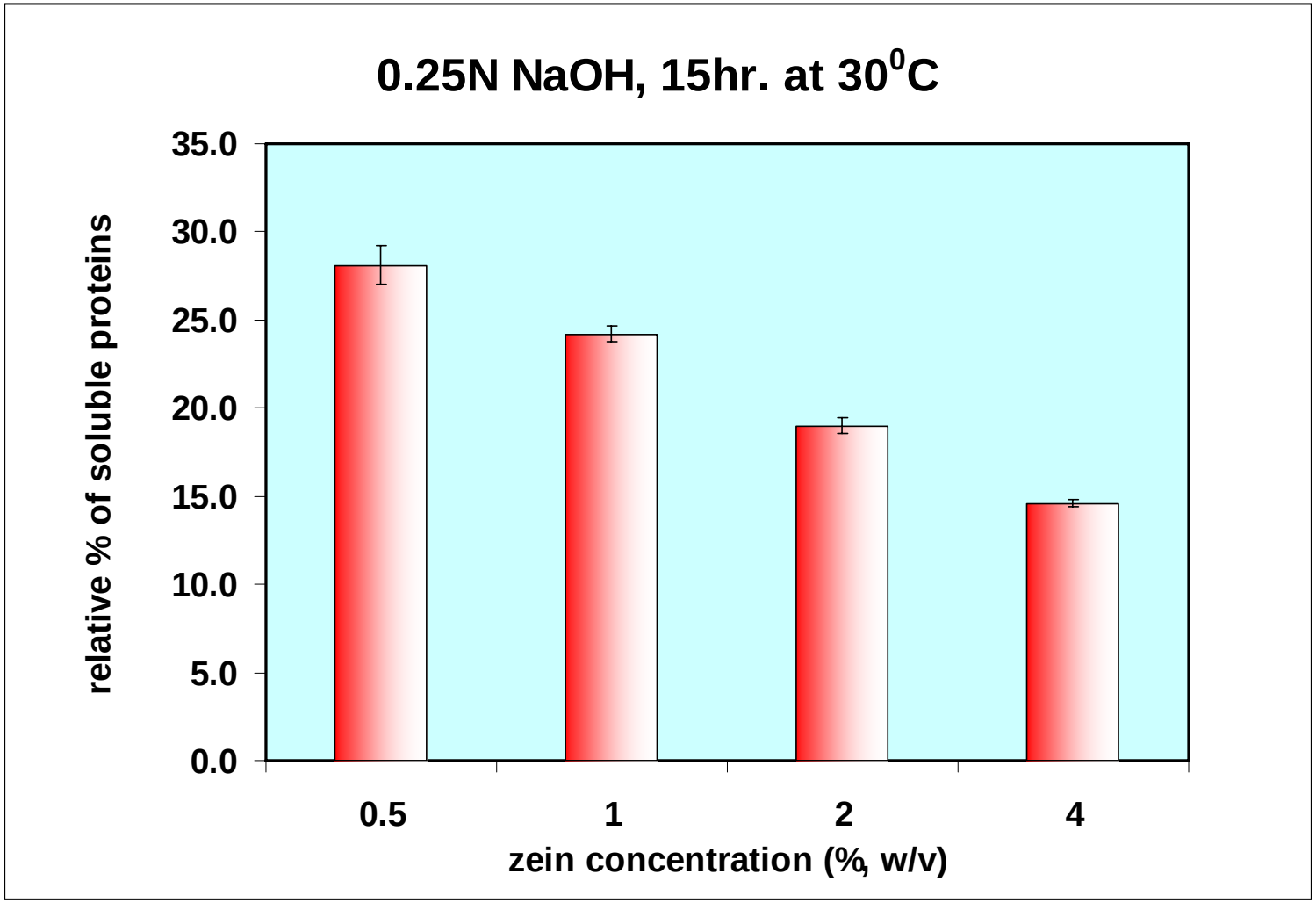
Effect of deamidation conditions on DD:



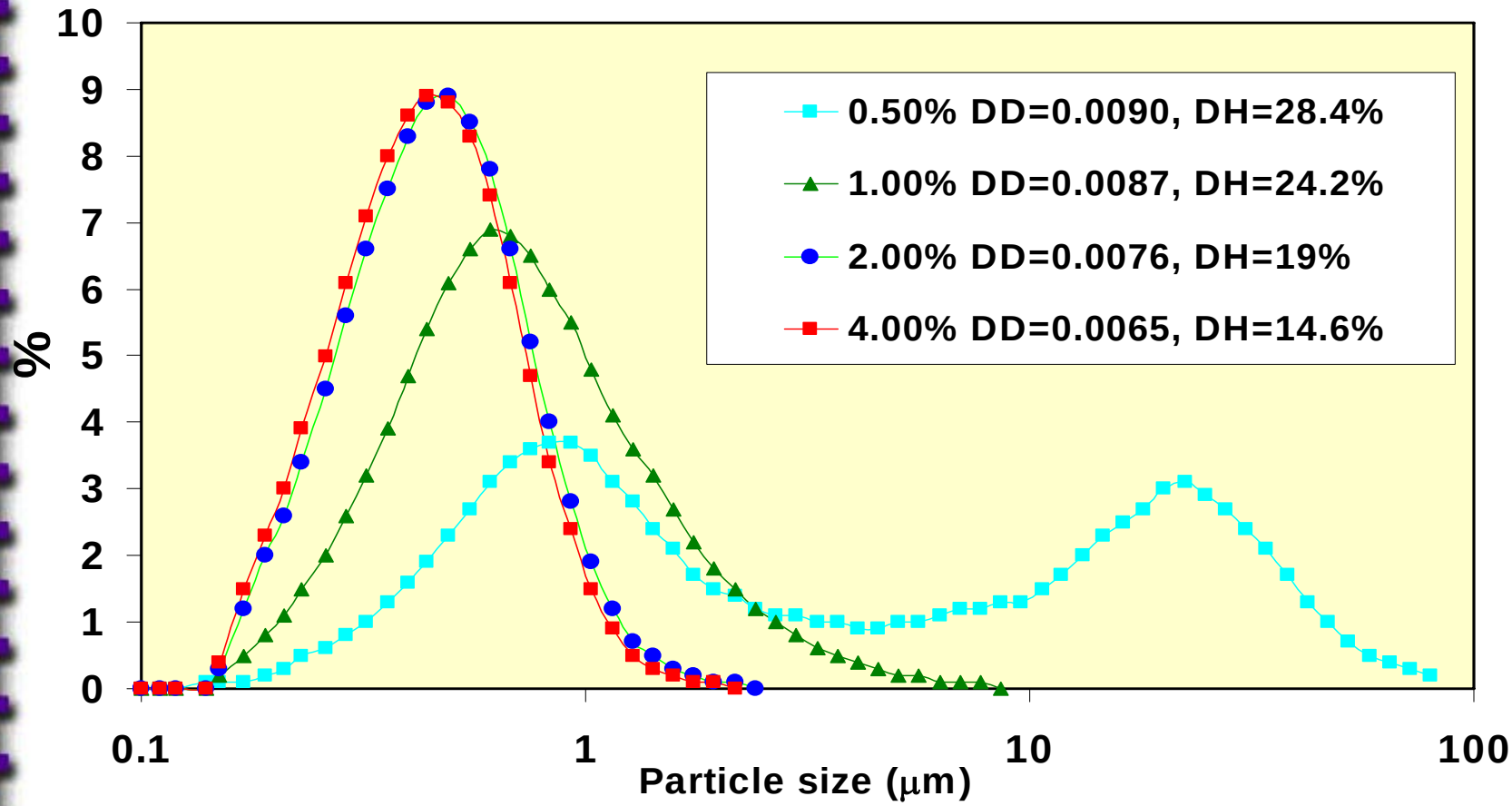
Effect of deamidation conditions on DH:



Effect of deamidation conditions on DH:



PSD of zein-stabilized emulsion containing 10% w/w oil. De-amidation conditions: 0.25N NaOH, 15hr. at 30°C, final pH=7.0.

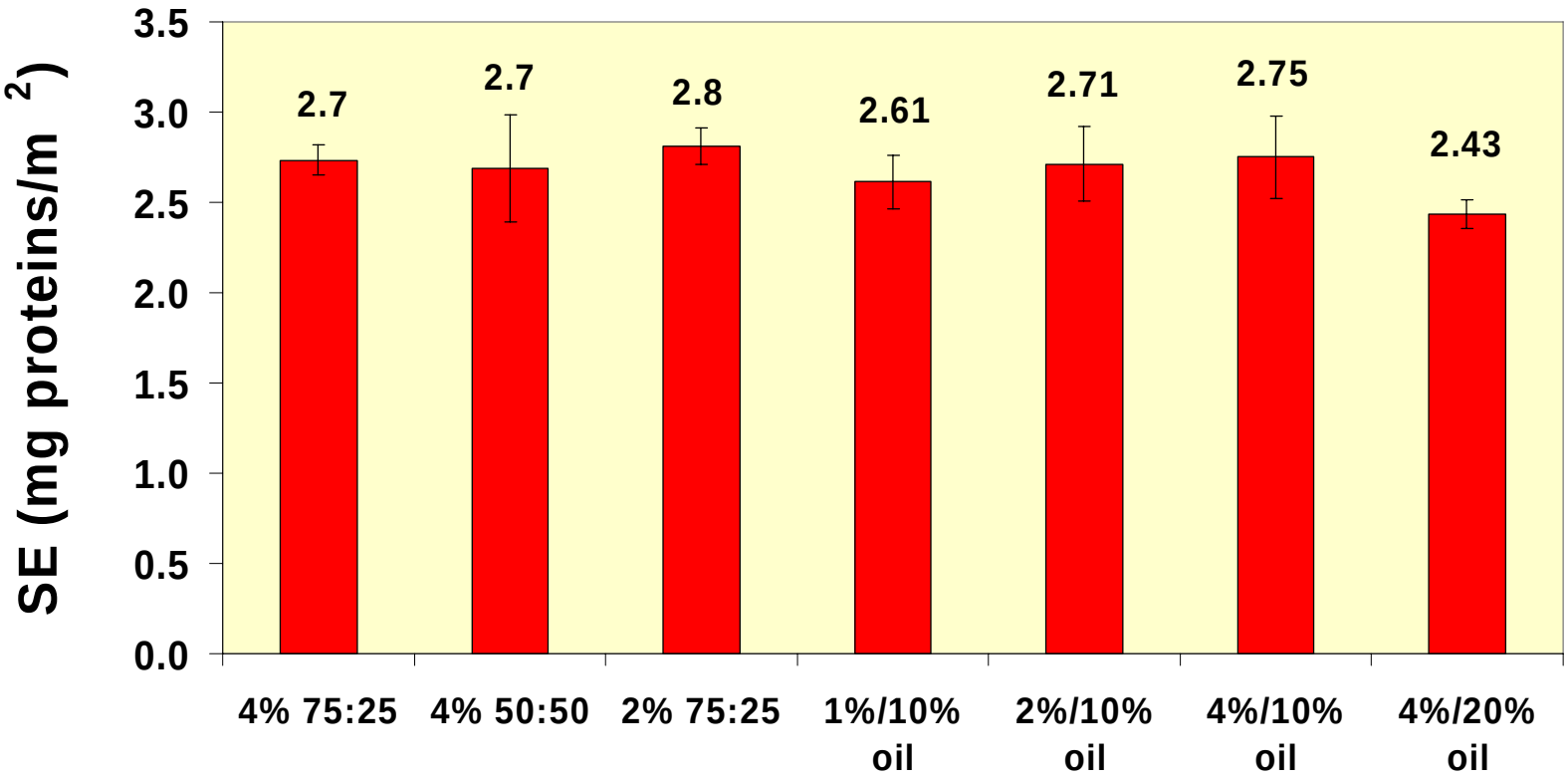


d_{32} in treated-zein-stabilized CIWE

Emulsion	Composition				DD*	DH %
	BE	BE after 24hr @ 4C	FE, DE 7.5	FE, DE 18		
1%zein 10%oil	0.54	0.51	0.63	0.62	0.0087	24.2
2%zein 10%oil	0.39	0.40	0.42	0.39	0.0076	19.0
4%zein 10%oil	0.37	0.38	0.45	0.38	0.0065	14.6
4%zein 20%oil	0.41	0.45	0.61	0.47	0.0065	14.6

*DD – mg NH3/mg protein

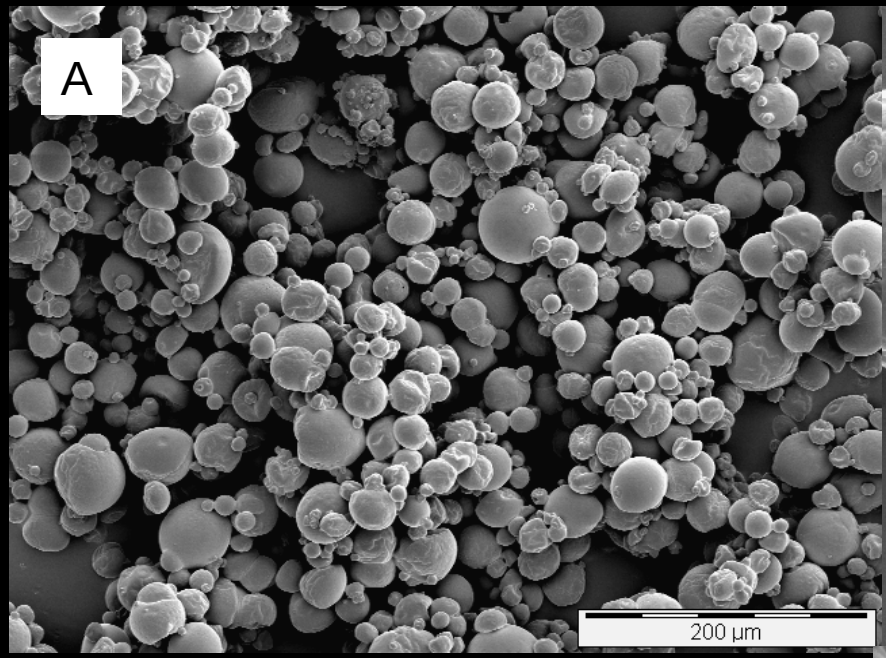
Surface Excess

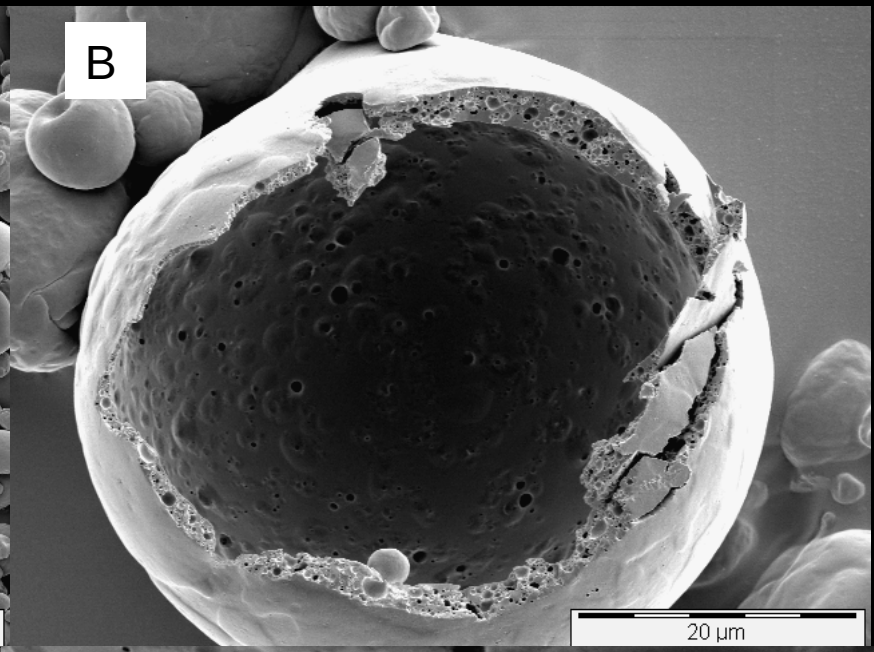


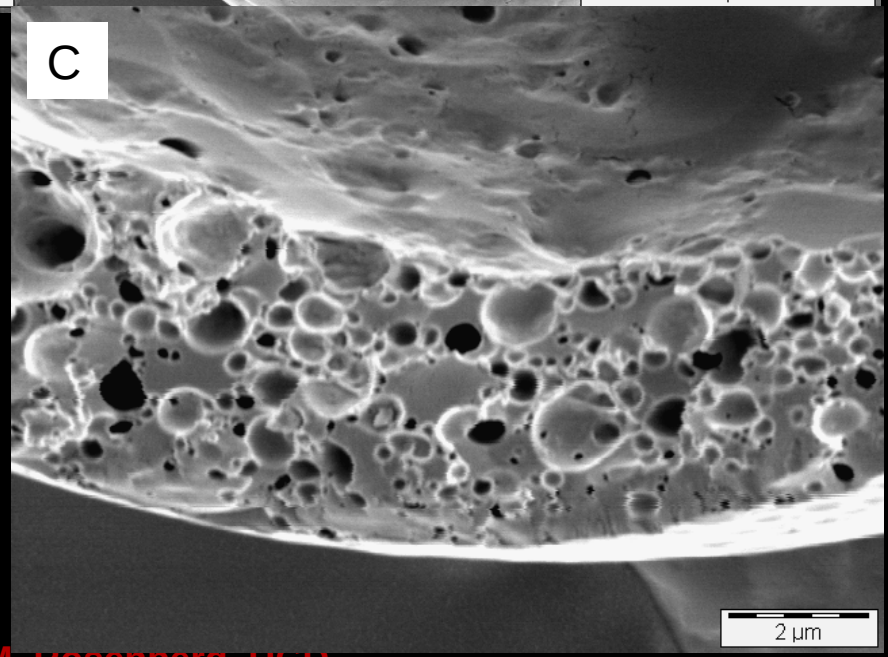
Effect of deamidation on surface excess. CIWE: protein – 4%; oil – 20%

Incubation time	SE (mg proteins/m^2)	DD*	DH (%)
15hr	2.43	0.0063	14.2
24hr	1.75	0.0091	16.7
34hr	1.21	0.0122	18.1
48hr	0.74	0.0158	20.5

*DD – mg NH3/mg protein







Zein microcapsules (dry basis):

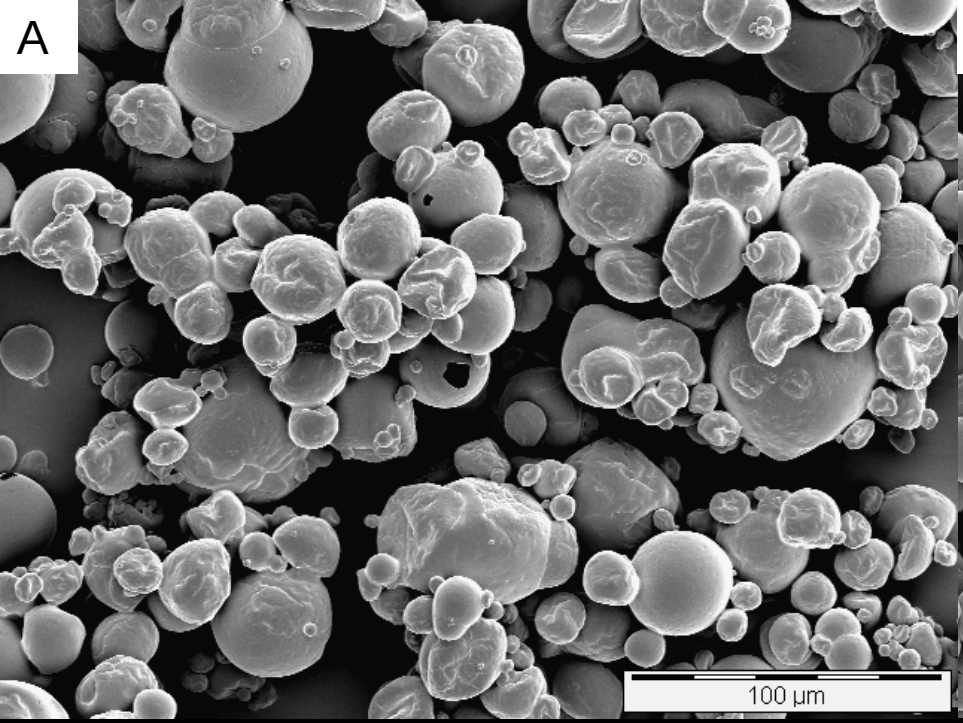
6.1% zein,

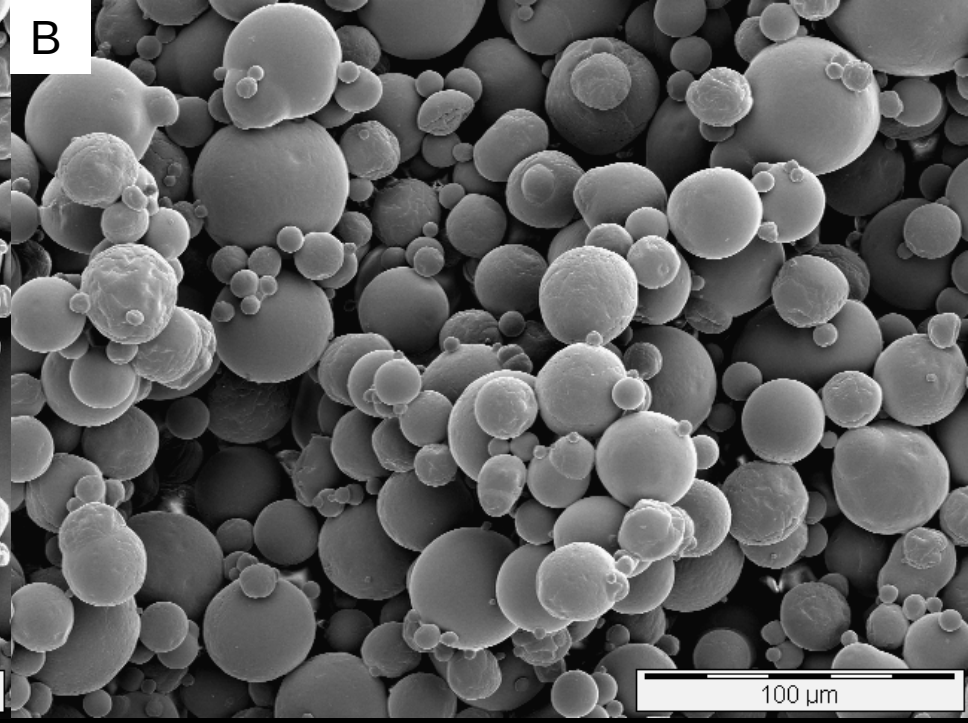
25% oil,

68.9% MD.DE 7.5

Drying conditions:

Ti = 160°C, To = 80°C.





Effect of DE value of outer topography.

Zein microcapsules (dry basis):

A = 12.5% zein,
25% oil,
62.5% DE 7.5.

B = 12.5% zein,
25% oil,
62.5% DE 18

Drying conditions:

Ti = 160°C, To = 80°C.

Microencapsulation Efficiency

Powder		MEE			DD(mg ammonia /mg protein)	DH %
Capsules	DE value	2.5 min	5min	15min		
4%/50:50	7.5	32.4 $^{A\,b}$	33.1 $^{A\,b}$	26.5 $^{B\,b}$	0.0063 ^{b}	14.2 ^{b}
4%/50:50	18	53.4 $^{A\,a}$	54.3 $^{A\,a}$	48.8 $^{B\,a}$		
4%/75:25	7.5	86.8 $^{A\,b}$	85.3 $^{B\,b}$	75.3 $^{C\,b}$	0.0065 ^{b}	14.1 ^{b}
4%/75:25	18	88.2 $^{A\,a}$	86.0 $^{B\,a}$	86.0 $^{B\,a}$		
2%/75:25	7.5	87.9 $^{A\,a}$	87.7 $^{A\,a}$	82.3 $^{B\,b}$	0.0074 ^{a}	19.0 ^{a}
2%/75:25	18	87.2 $^{A\,b}$	87.7 $^{A\,a}$	84.9 $^{B\,a}$		

CONCLUSIONS

- SPI and zein can serve as functional microencapsulating agents for lipids encapsulation.
- Utilization of zein requires a controlled deamidation stage.
- Treated zein is effective in forming and stabilizing CIWE.
- Treated zein provides, for the first time ever, means to prepare microcapsules in an all aqueous environment
- SPI and treated zein can be utilized for preparing composite microcapsules consisting of protein-coated oil droplets embedded in MD-based wall.
- Deamidation conditions affect surface excess.
- Type of MD affects MEE
- Surface excess obtained with SPI is lower than that obtained with treated zein.